Quikscat Geophysical Model Function and High-Resolution Imaging of Tropical Cyclone Winds

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The feasibility of Quikscat for the measurements of tropical cyclone wind fields has been investigated with the data from the CAL/VAL period. We have examined about fifty revs of Quikscat data from seven hurricanes. The issues under investigation are whether it is possible to measure hurricane force winds with the Quikscat and how well the measurements can be performed.

To address these issues, we examine the collocated Quikscat $\sigma 0$ data, the SSM/I rain rates, and the wind fields from Holland's tropical wind field model. The parameters required for the tropical wind field model are derived from the NHC track analysis. We bin the Quikscat $\sigma 0$ data as a function of wind speed, direction and rain rates. It is found that the Quikscat $\sigma 0$s increase by about 3-4 dB from 20-60 m/s for the inner beam (horizontal polarization at 46° incidence) and about 2-3 dB for the outer beam (vertical polarization at 54° incidence). This provides a direct indication that it is possible to measure the hurricane wind speeds at up to 60 m/s with a spaceborne Ku-band scatterometer. In comparison with the NSCAT2 geophysical model function (GMF), the Quikscat $\sigma 0$ is lower than the predictions of NSCAT2 GMF. The difference is small at 20 m/s and increases to 2-3 dB above 30 m/s wind speed. This is consistent with the fact that the Quikscat/NSCAT2 winds underestimate the strength of hurricanes. A correction of the NSCAT2 GMF with the observed difference is proposed.

Three types of Quikscat winds were compared. The first one (QS) is the Quikscat wind product processed with the NSCAT2 geophysical model function (GMF) at a wind vector cell (WVC) resolution of 25 km. The second one (QS-HIRES) is the winds processed at a WVC resolution of 12.5 km with the NSCAT2 GMF. The third one (QS-HIRES/TC) is processed at a WVC resolution of 12.5 km with an improved GMF for high winds (>20 m/s). By comparison with the best track analysis from the National Hurricane Center (NHC), the QS winds are usually lower than the NHC estimates of maximum sustained wind speeds by 10-30 m/s. The other deficiency of the QS winds is due to the limited antenna resolution of Quikscat: The eyes of the hurricanes are usually blurred in the QS image of 25 km resolution. With an improvement of the WVC resolution by a factor of two, it becomes relatively easy to identify the hurricane eye in the QS-HIRES product. The location of the eye estimated from the QS-HIRES images has a good agreement with the NHC best track analysis. Another advantage of 12.5 km resolution is the reduction of wind gradient effects near the eye wall. It is estimated that the speed bias due to the wind gradient near the eye wall is reduced by about 50%. Finally, we show the improvements to the wind speed estimates by a more accurate GMF for high winds.

QUIKSCAT GEOPHYSICAL MODEL FUNCTION AND HIGH RESOLUTION IMAGING OF TROPICAL CYCLONE WINDS

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OUTLINE

- INTRODUCTION
- GEOPHYSICAL MODEL FUNCTION FOR HIGH WINDS AND RAIN
- QUIKSCAT OBSERVATIONS OF HURRICANE FLOYD
- SUMMARY

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INTRODUCTION

- PRESENT QUIKSCAT WINDS UNDERESTIMATE THE INTENSITY OF HURRICANES
- KEY ISSUES FOR THE SCATTEROMETER OBSERVATIONS OF TROPICAL CYCLONES
  - HIGH WIND MODEL FUNCTION
  - EFFECTS OF RAIN
  - WIND GRADIENT

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APPROACH

- ESTIMATE THE KU-BAND GMF WITH COLLOCATED QSCAT SIGMA0/SSMI RAIN/HOLLAND'S TC MODEL TO EXAMINE
  - THE GMF
  - EFFECTS OF RAIN ON SIGMA0
- COMPARE QUIKSCAT 12.5 KM and 25 KM WINDS
  - WIND GRADIENT
  - HURRICANE CENTER AND SIZE OF EYE WALL

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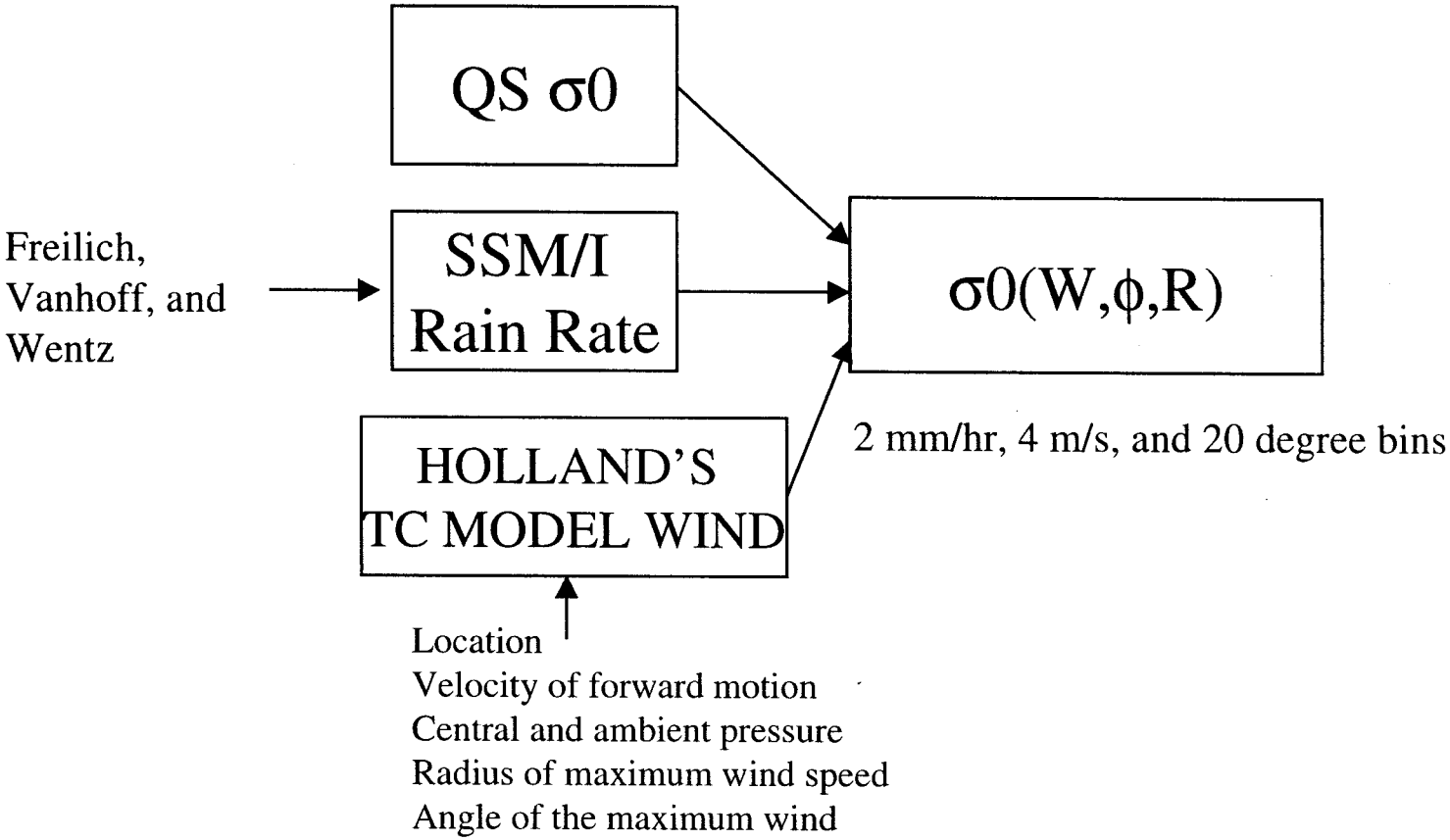
GMF FOR HIGH WIND AND RAIN

- **THE APPROACH IS BASED ON YOUNG'S TECHNIQUE (JGR 1993) FOR THE ESTIMATE OF GEOSAT ALTIMETER WIND SPEED ALGORITHM**



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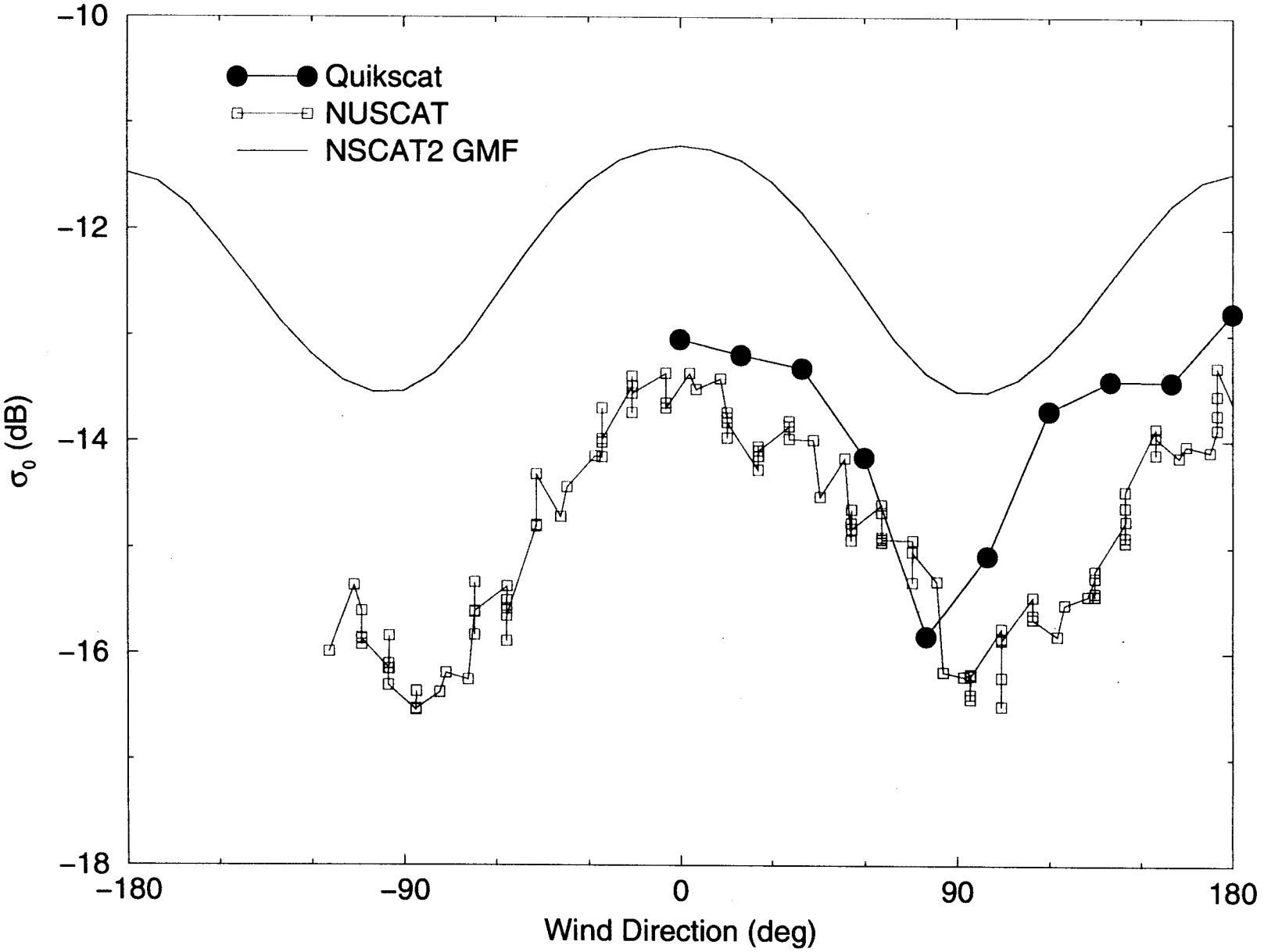
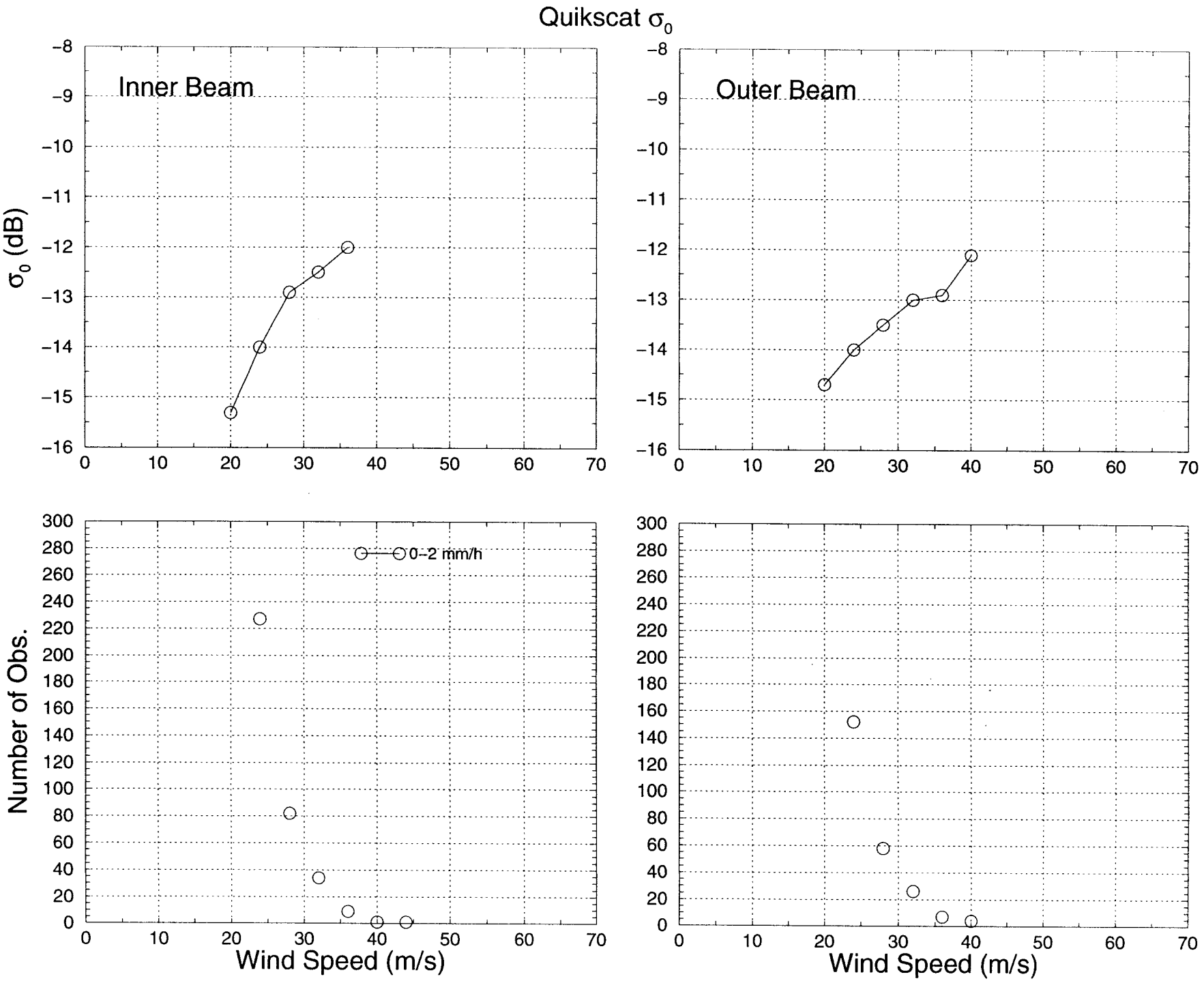
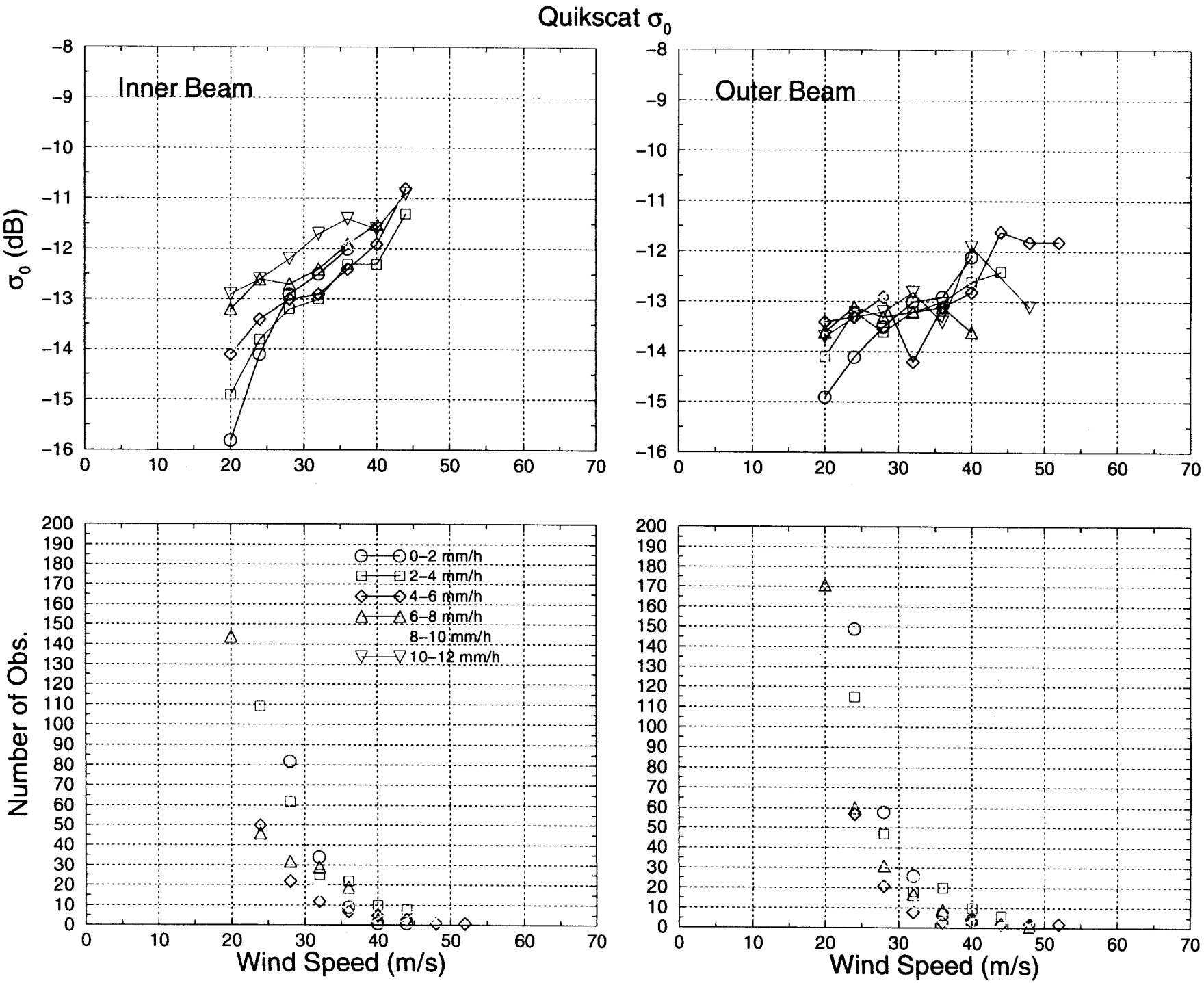
PACIFIC AND ATLANTIC HURRICANES AUGUST-SEPTEMBER 1999

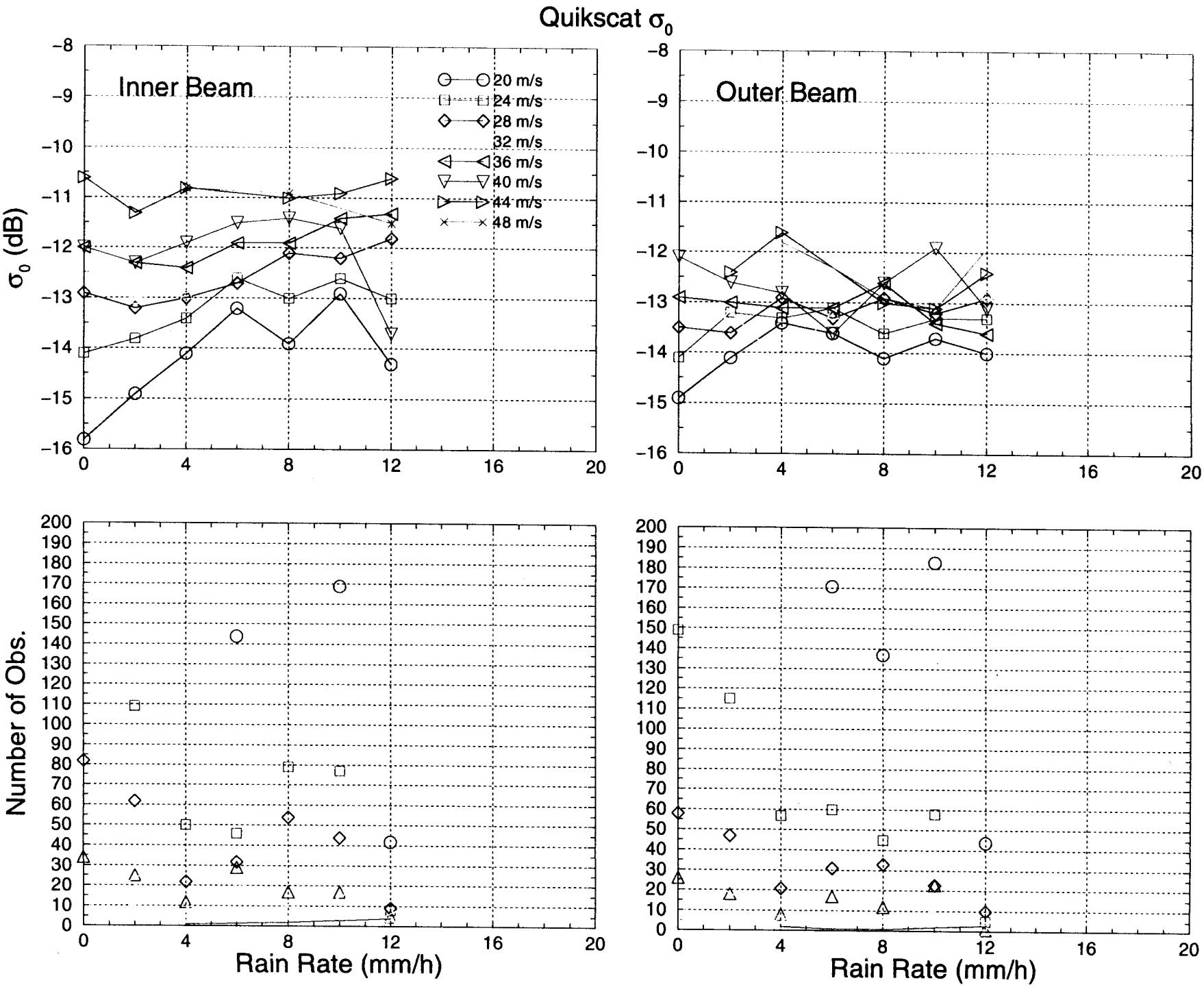
TC	TIME	LOCATION	NUMBER OF QSCAT PASSES
BRET	AUGUST	GULF	3
CINDY	AUGUST	ATLANTIC	10
DENNIS	AUGUST	ATLANTIC	12
FLOYD	SEPTEMBER	ATLANTIC	8
GERT	SEPTEMBER	ATLANTIC	2
EUGENE	AUGUST	PACIFIC	5
DORA	AUGUST	PACIFIC	18

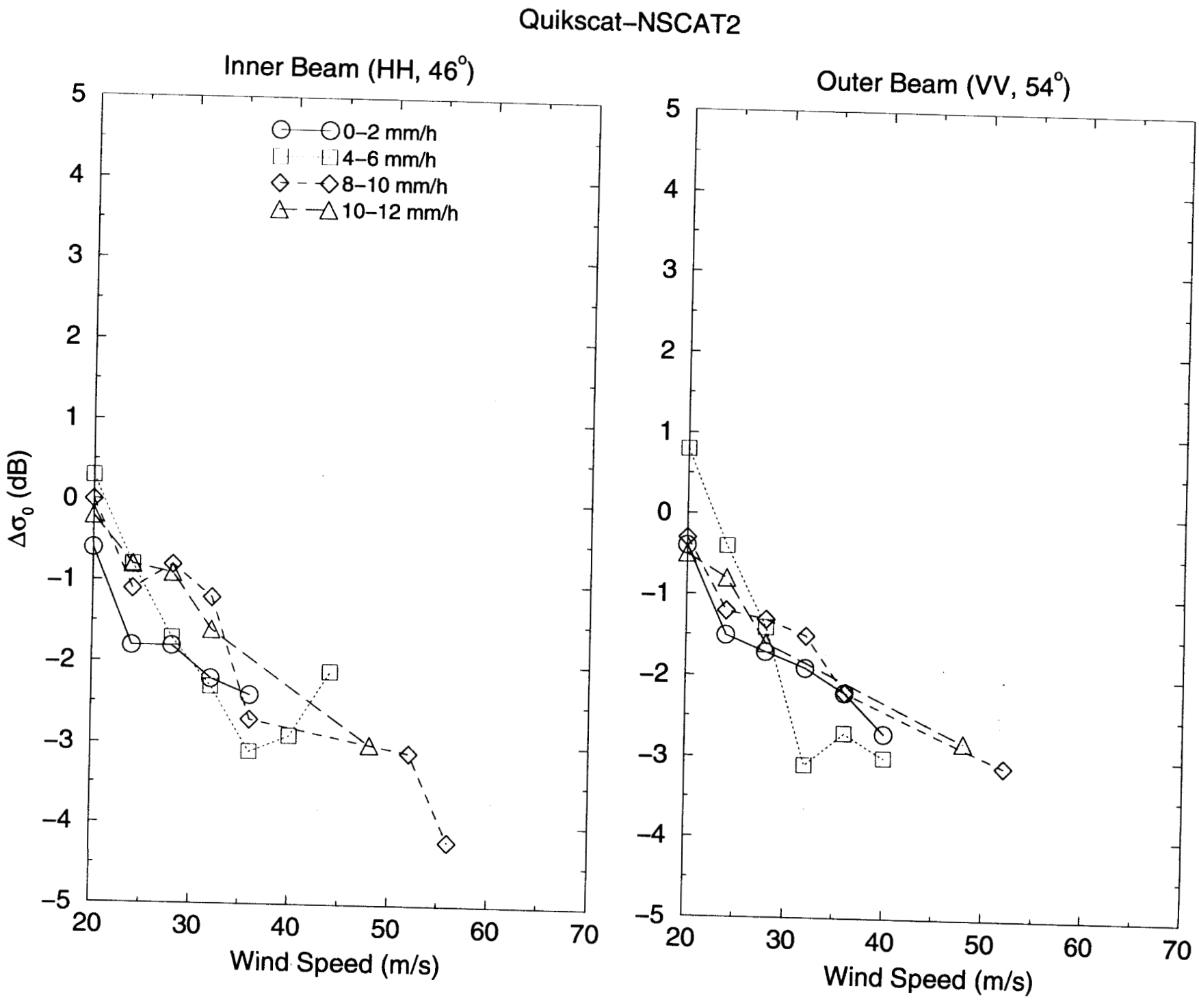
QUIKSCAT, NUSCAT, and NSCAT2 Comparison (54 deg, 24 m/s, 0 mm/h)

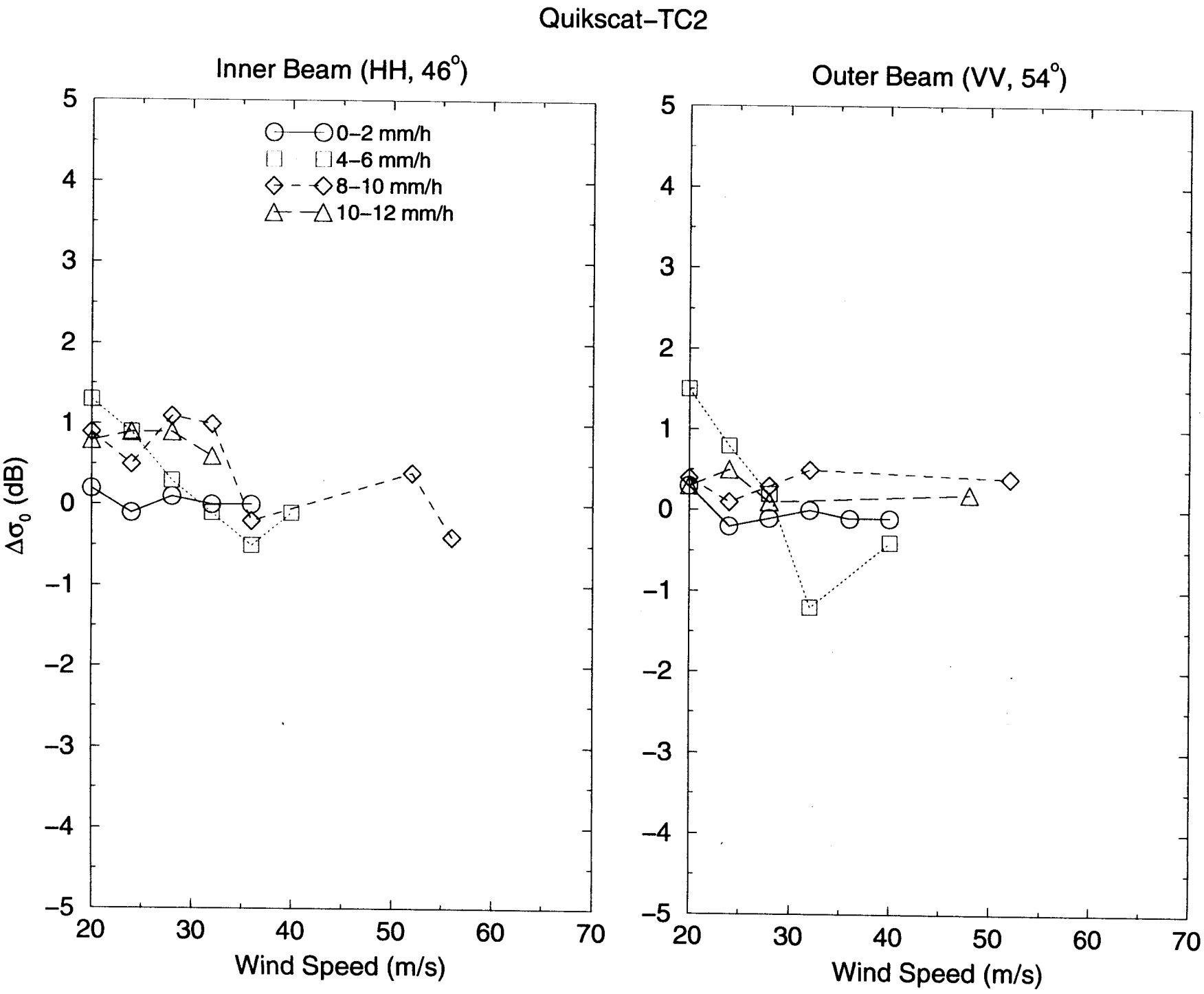


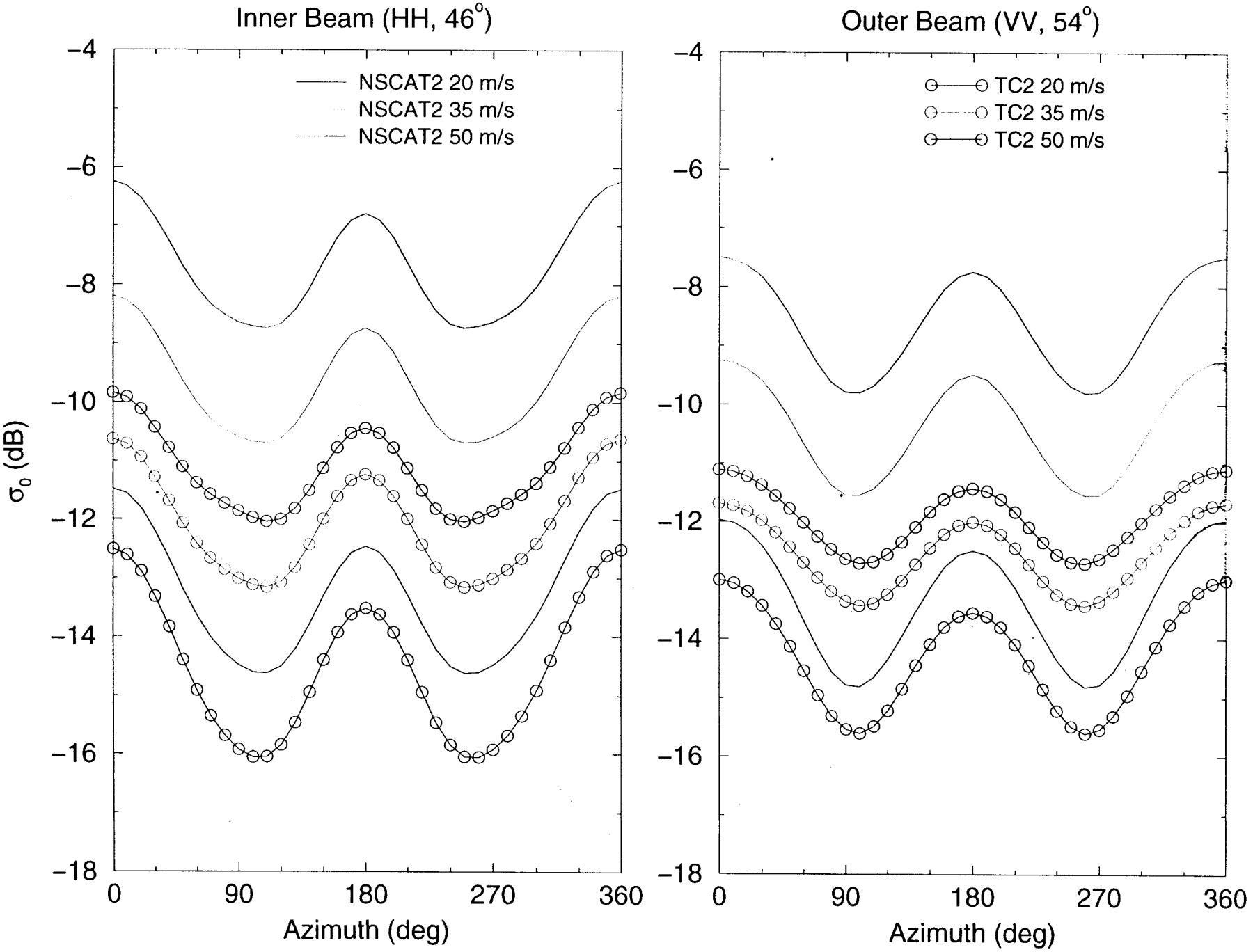

Quikscat σ_0
Inner Beam
Outer Beam
σ_0 (dB)
Number of Obs.
0–2 mm/h
Wind Speed (m/s)
Wind Speed (m/s)

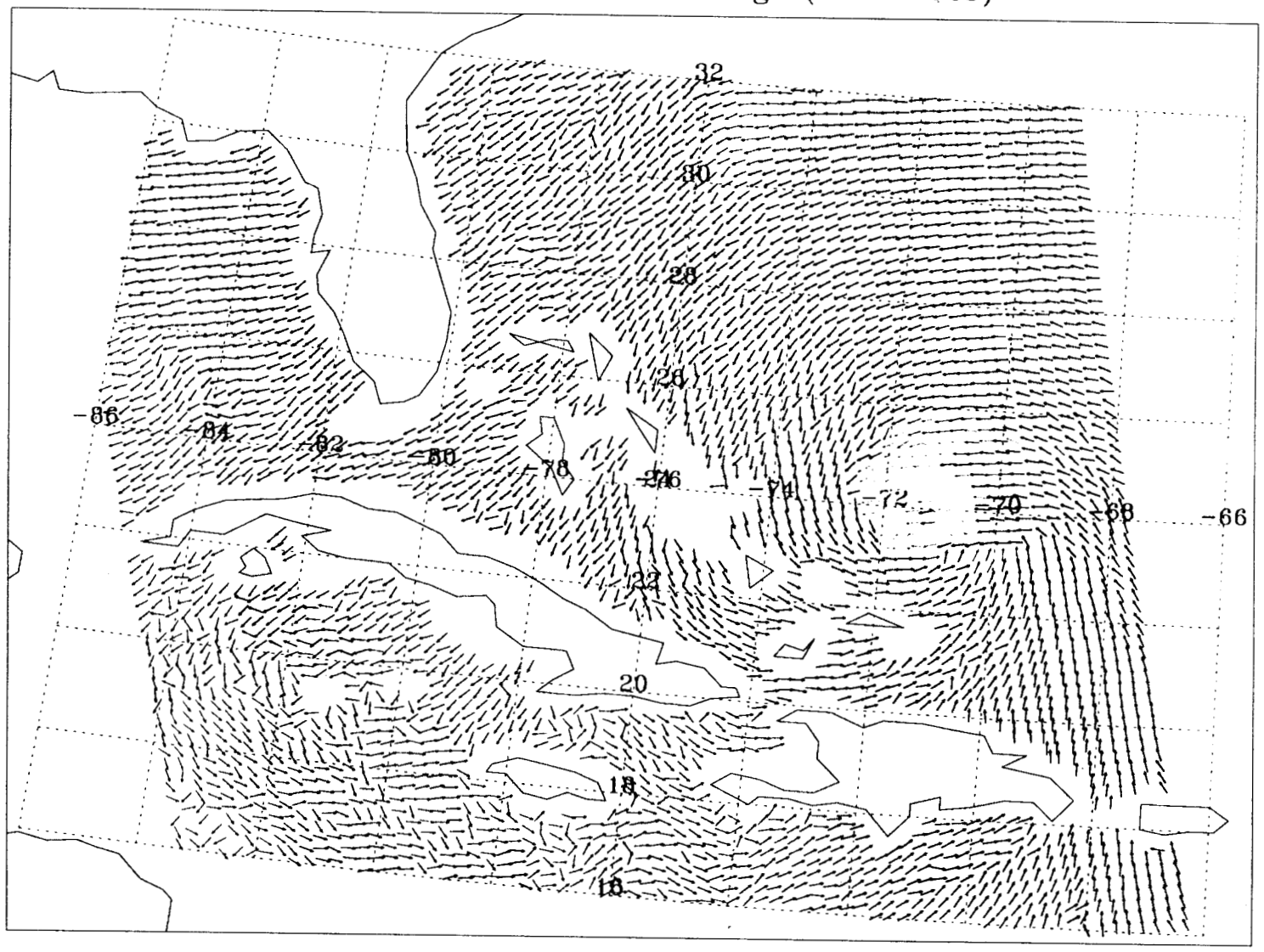

Quikscat σ_0
Inner Beam
Outer Beam
σ_0 (dB)
Number of Obs.
Wind Speed (m/s)
Wind Speed (m/s)
0–2 mm/h
2–4 mm/h
4–6 mm/h
6–8 mm/h
8–10 mm/h
10–12 mm/h


Quikscat σ_0
Inner Beam
Outer Beam
20 m/s
24 m/s
28 m/s
32 m/s
36 m/s
40 m/s
44 m/s
48 m/s
σ_0 (dB)
Number of Obs.
Rain Rate (mm/h)
Rain Rate (mm/h)

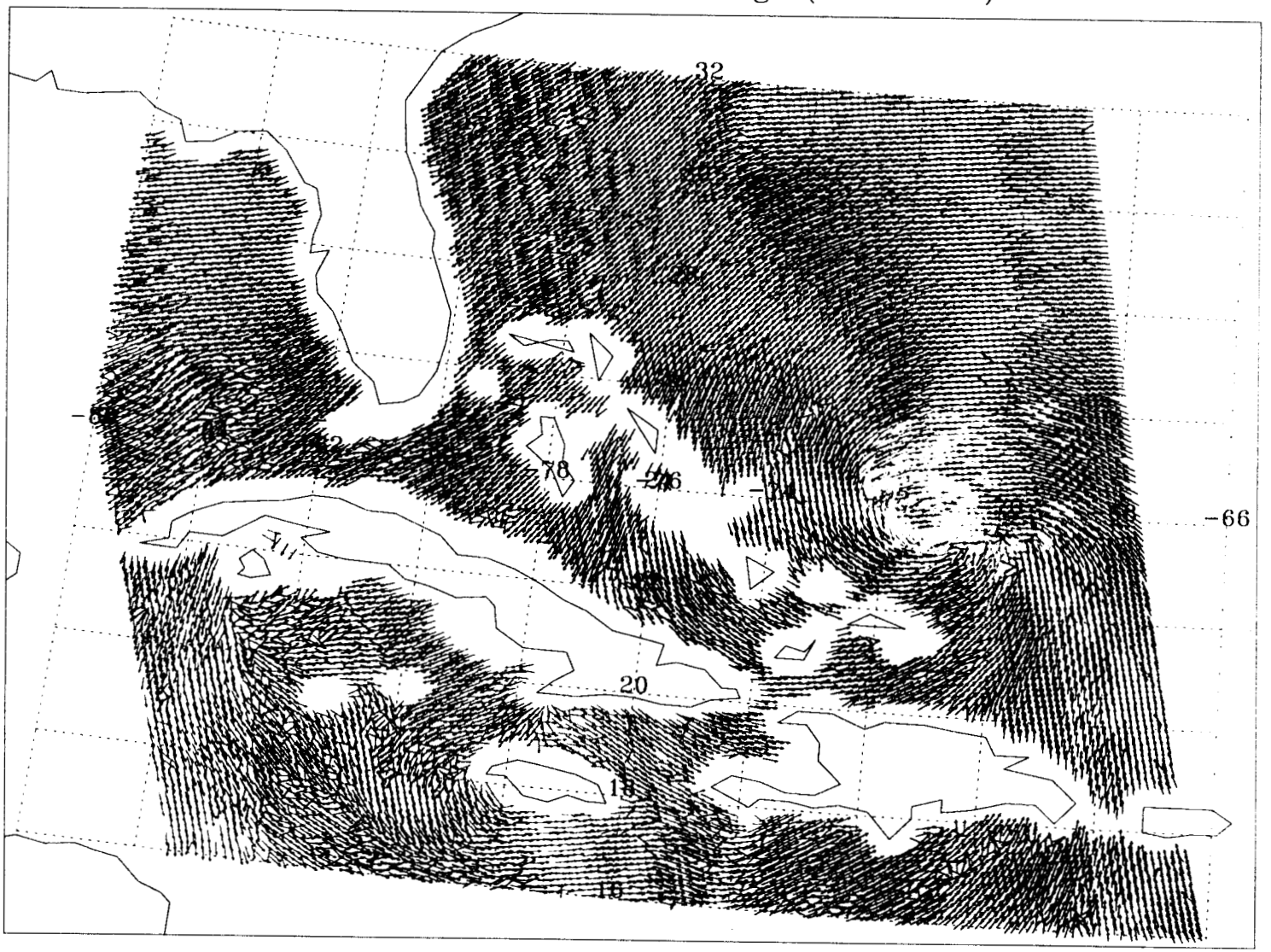

Quikscat–NSCAT2
Inner Beam (HH, 46°)
Outer Beam (VV, 54°)
0–2 mm/h
4–6 mm/h
8–10 mm/h
10–12 mm/h
Δσ0 (dB)
Wind Speed (m/s)
Wind Speed (m/s)


Quikscat–TC2
Inner Beam (HH, 46°)
Outer Beam (VV, 54°)
0–2 mm/h
4–6 mm/h
8–10 mm/h
10–12 mm/h
Δσ0 (dB)
Wind Speed (m/s)
Wind Speed (m/s)

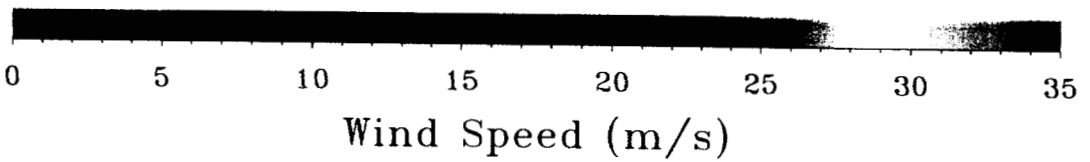

NSCAT2 and TC2 GMF
Inner Beam (HH, 46°)
Outer Beam (VV, 54°)
NSCAT2 20 m/s
NSCAT2 35 m/s
NSCAT2 50 m/s
TC2 20 m/s
TC2 35 m/s
TC2 50 m/s
σ0 (dB)
−4
−6
−8
−10
−12
−14
−16
−18
0
90
180
270
360
Azimuth (deg)


QuikScat Wind Vector Coverage (Rev 01223)
32
30
28
26
24
22
20
18
16
86
84
82
80
78
76
74
72
70
68
66
Max Speed 31.9 m/s@ 24.4/-71.6
0
5
10
15
20
25
30
35
Wind Speed (m/s)

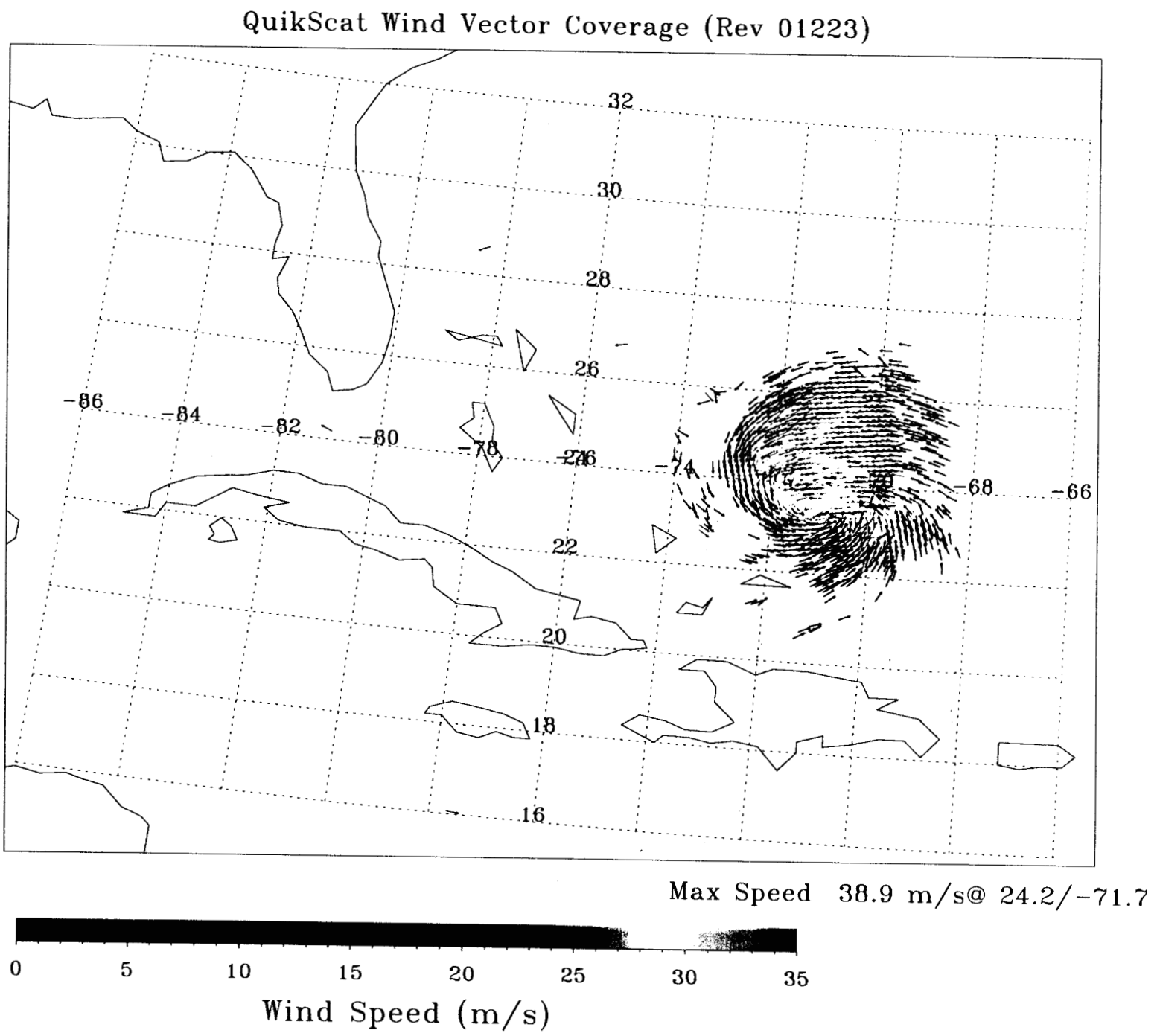
QuikScat Wind Vector Coverage (Rev 01223)



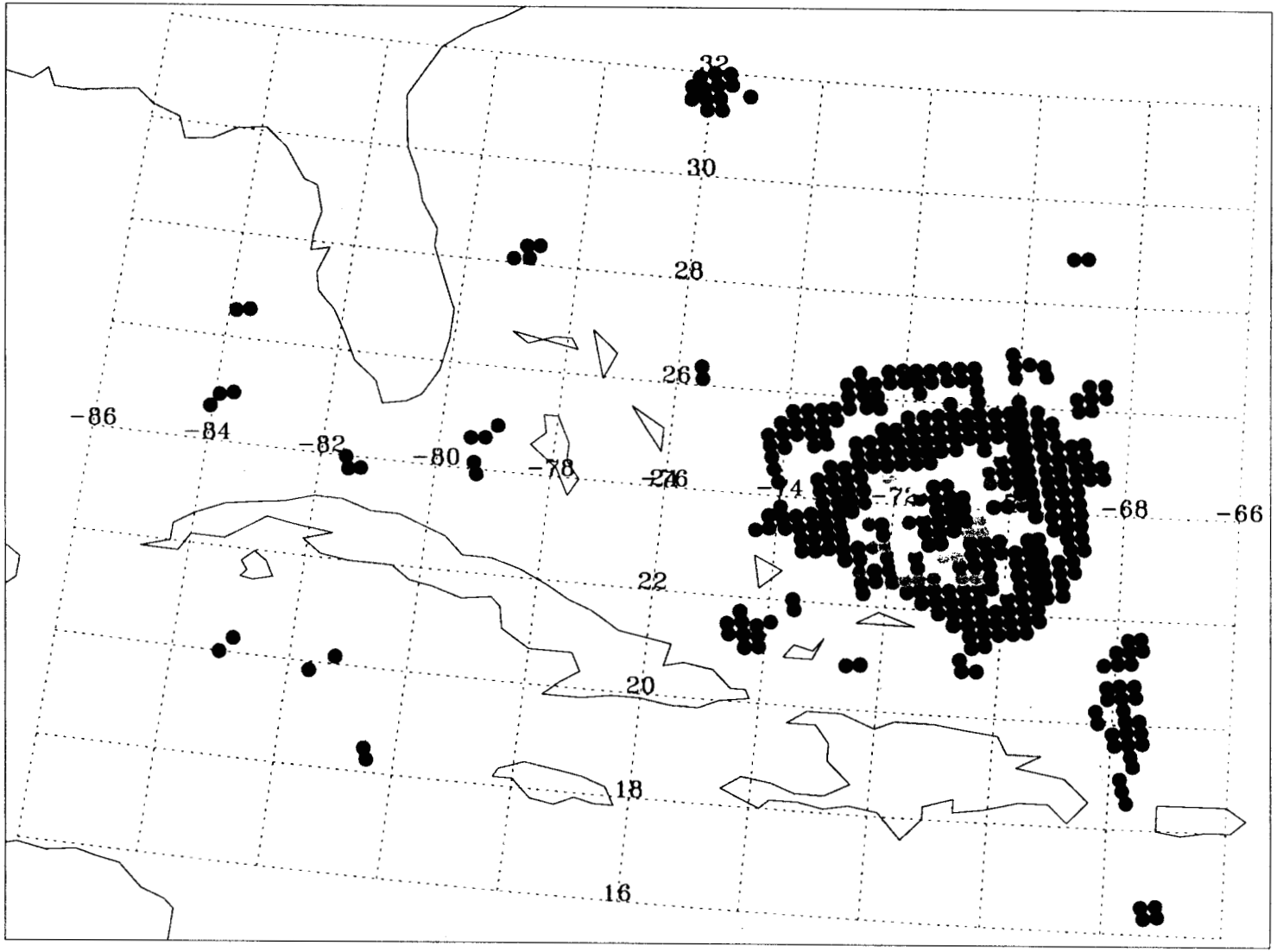
Max Speed 38.9 m/s@ 24.2/-71.7

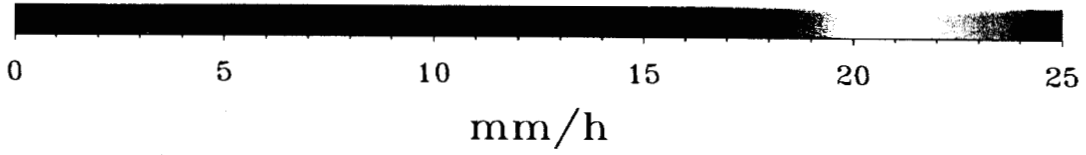


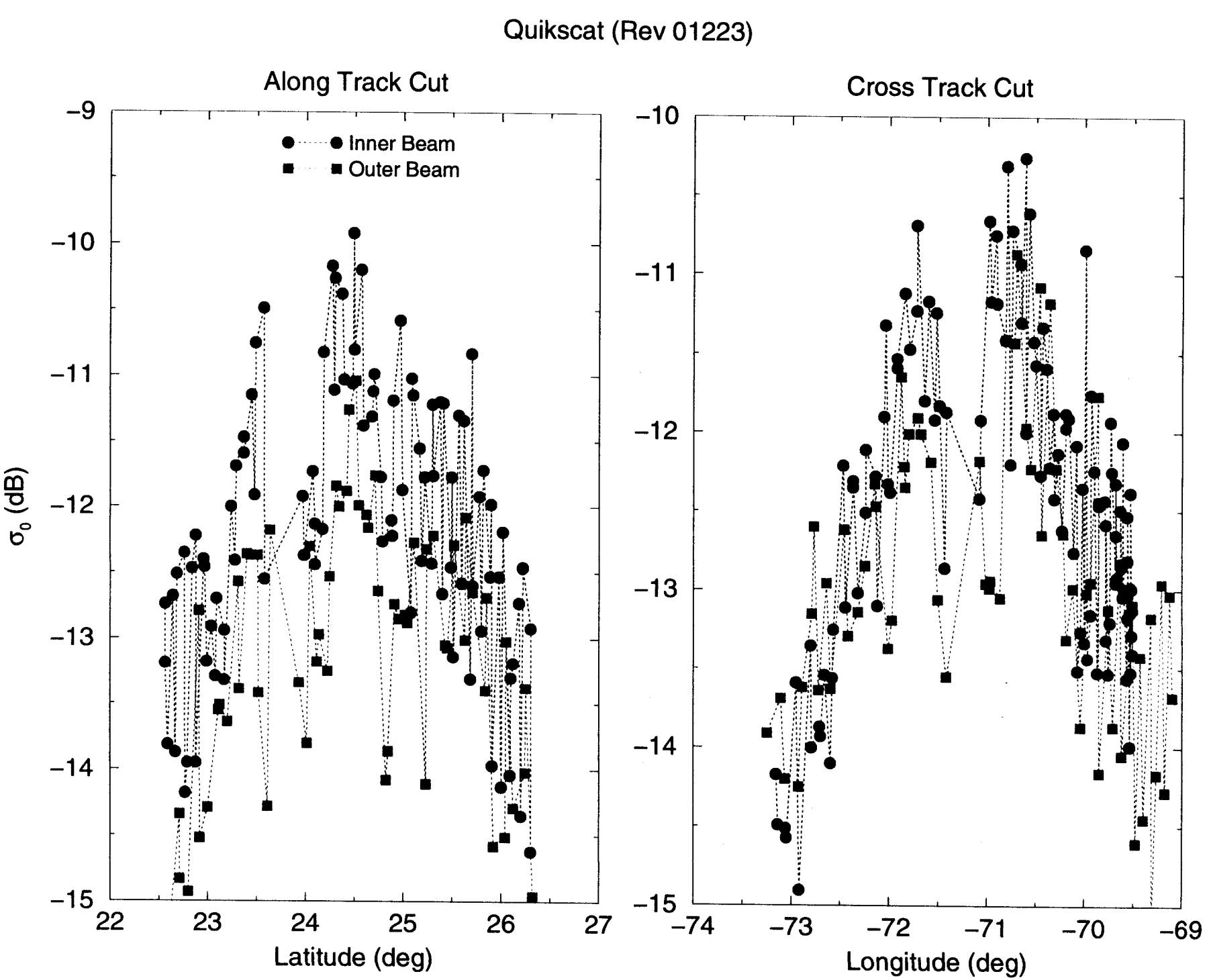
Wind Speed (m/s)

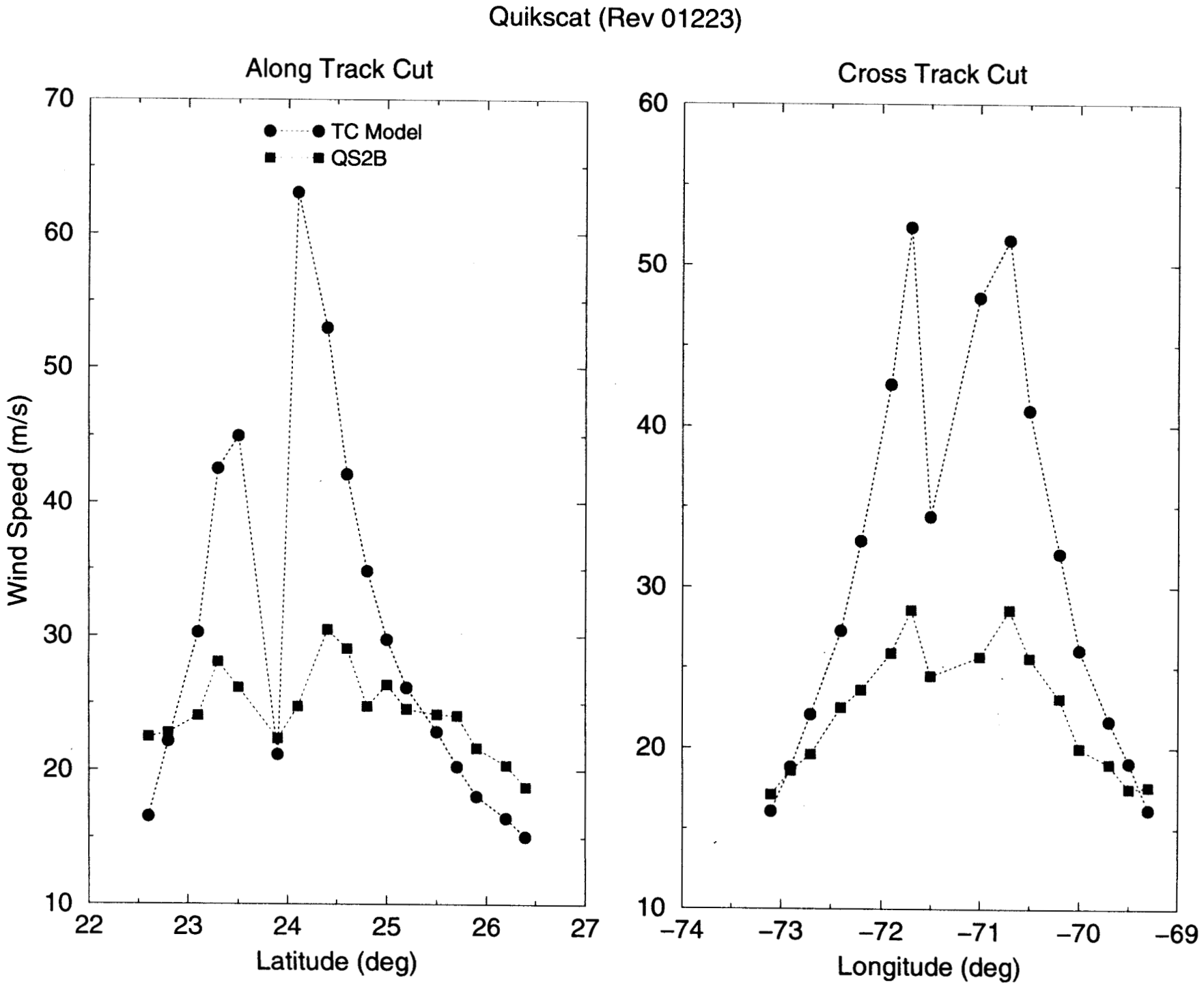

QuikScat Wind Vector Coverage (Rev 01223)
32
30
28
26
24
22
20
18
16
-86
-84
-82
-80
-78
-76
-74
-68
-66
Max Speed 38.9 m/s@ 24.2/-71.7
0
5
10
15
20
25
30
35
Wind Speed (m/s)

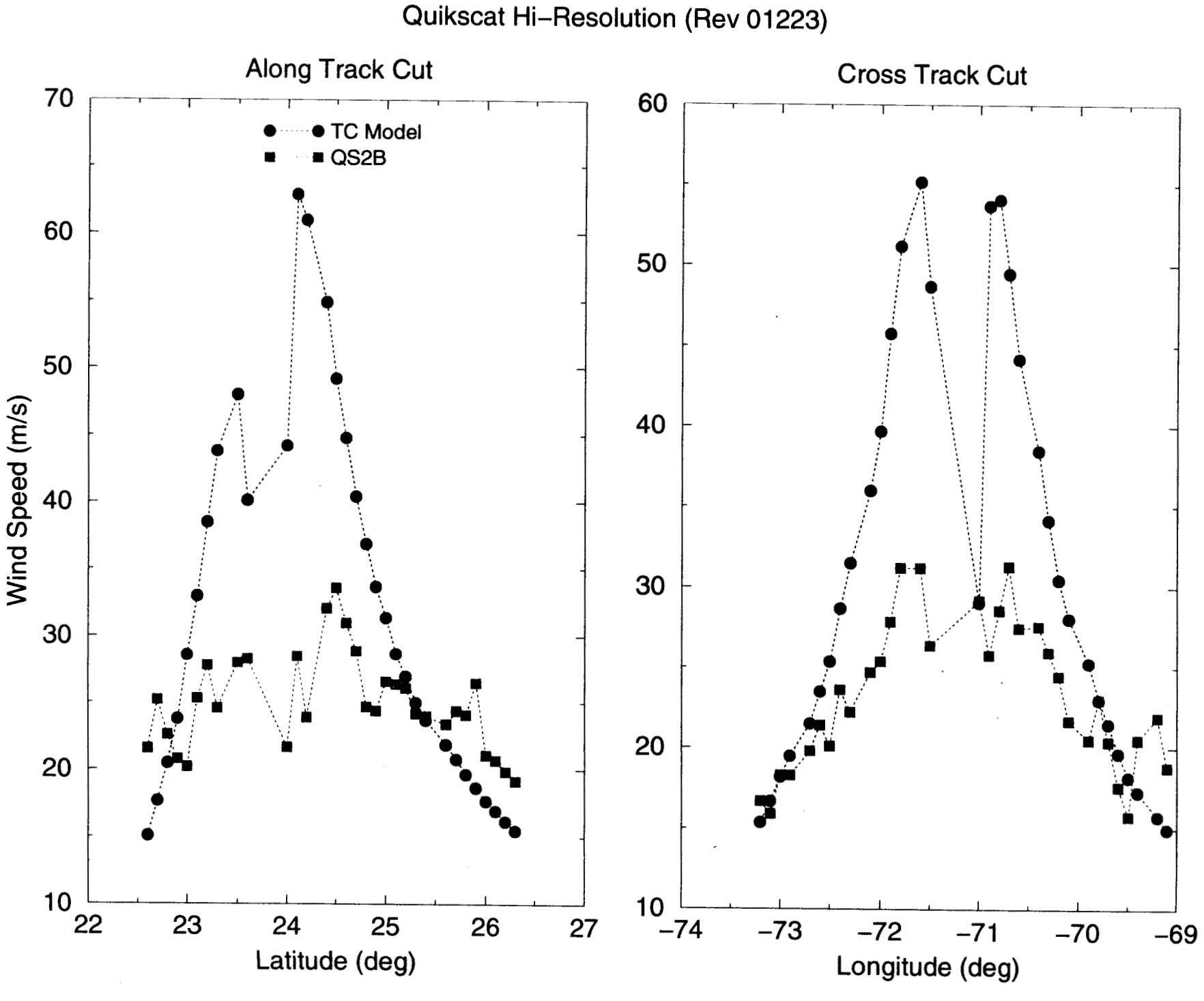
SSMI Rain Rate Coverage for Quikscat (Rev 01223)



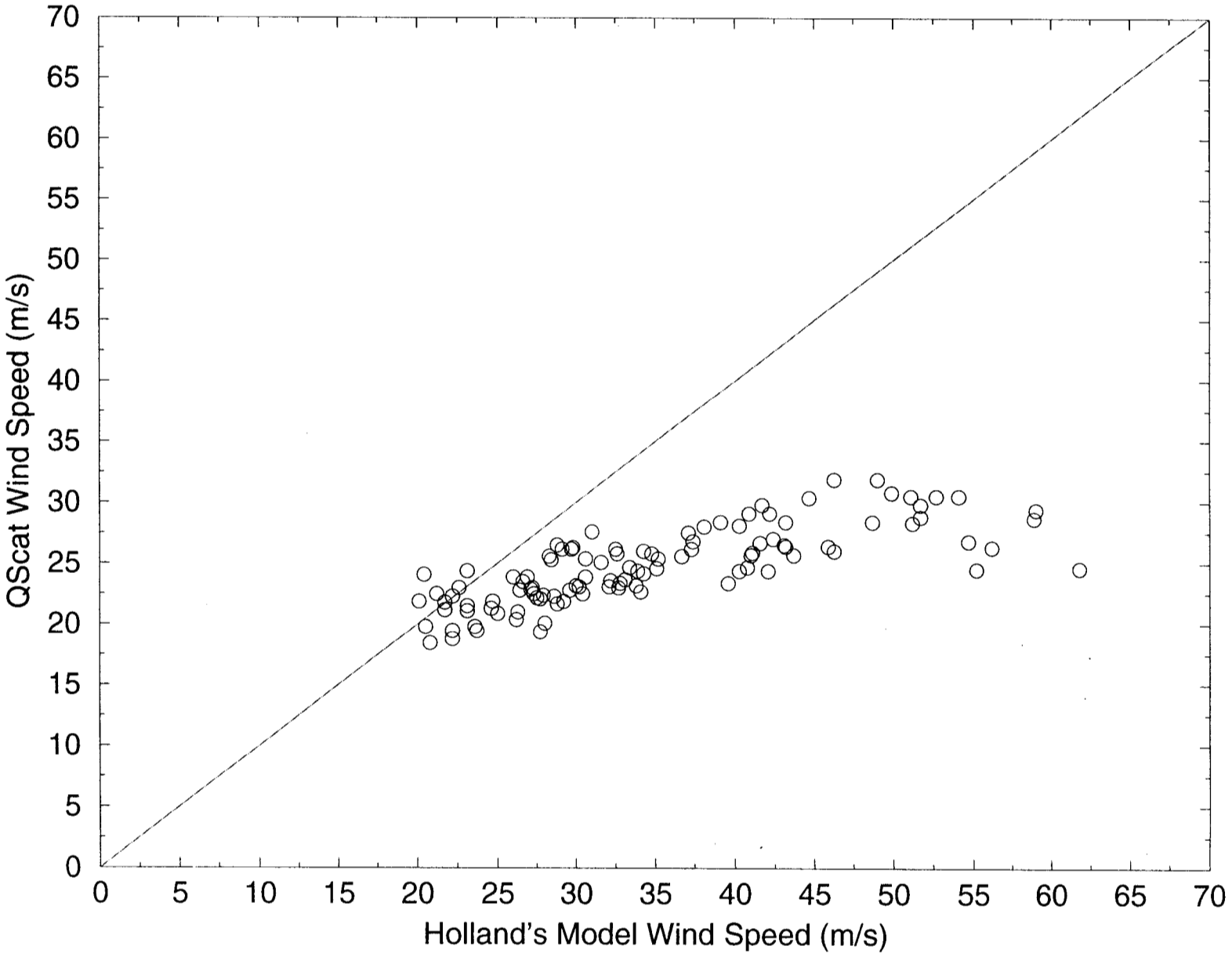


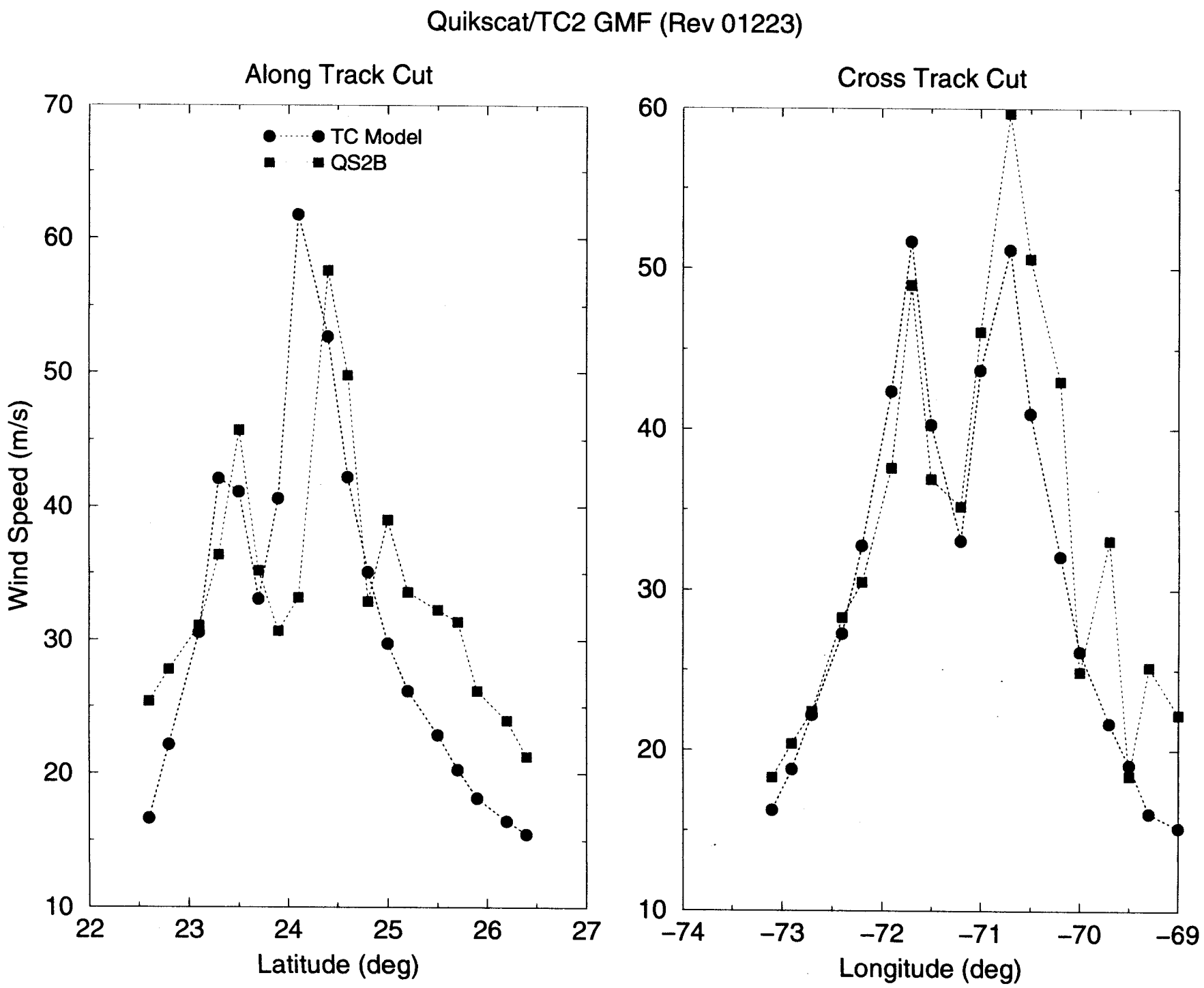

Quikscat (Rev 01223)
Along Track Cut
Cross Track Cut
Inner Beam
Outer Beam
σ0 (dB)
Latitude (deg)
Longitude (deg)
−9
−10
−11
−12
−13
−14
−15
22
23
24
25
26
27
−74
−73
−72
−71
−70
−69


Quikscat (Rev 01223)
Along Track Cut
Cross Track Cut
TC Model
QS2B
Wind Speed (m/s)
Latitude (deg)
Longitude (deg)
70
60
50
40
30
20
10
22
23
24
25
26
27
−74
−73
−72
−71
−70
−69

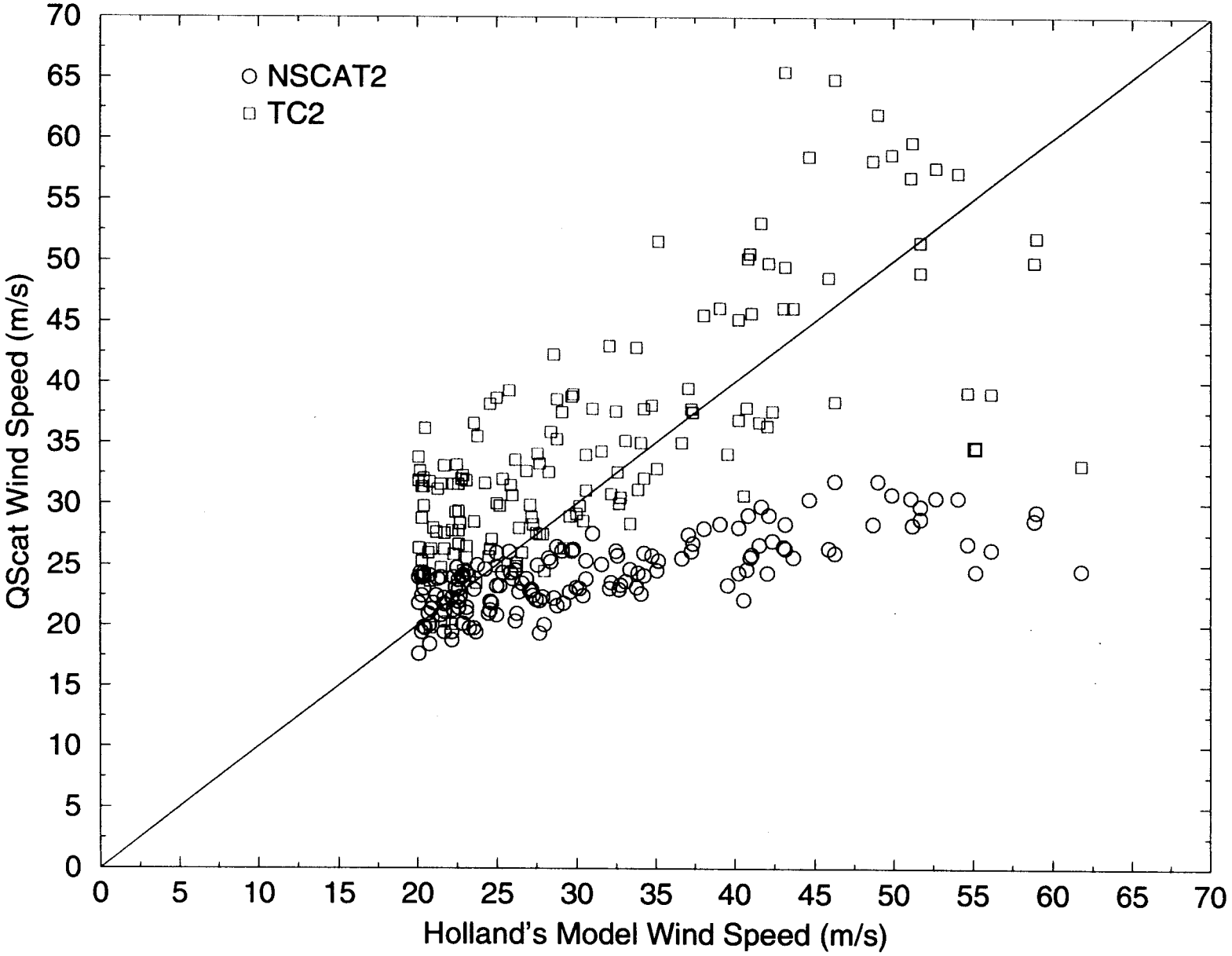

Quikscat Hi-Resolution (Rev 01223)
Along Track Cut
Cross Track Cut
TC Model
QS2B
Wind Speed (m/s)
Latitude (deg)
Longitude (deg)
70
60
50
40
30
20
10
22
23
24
25
26
27
−74
−73
−72
−71
−70
−69

Quikscat (Rev 01223) Floyd QS2B




Quikscat/TC2 GMF (Rev 01223)
Along Track Cut
Cross Track Cut
TC Model
QS2B
Wind Speed (m/s)
Latitude (deg)
Longitude (deg)
70
60
50
40
30
20
10
22
23
24
25
26
27
−74
−73
−72
−71
−70
−69

Quikscat/TC2 GMF (Rev 01223)



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SUMMARY

- QSCAT/NSCAT2 WINDS UNDERESTIMATE THE INTENSITY OF HURRICANES
- AN IMPROVED HIGH WIND GMF FOR QSCAT IS DEVELOPED
  - FURTHER IMPROVEMENTS TO BE MADE TO MODEL THE DEPENDENCE ON WIND DIRECTION AND RAIN
- RAIN INCREASES THE SIGMA0 FOR HIGH WINDS
  - EFFECTS MORE SIGNIFICANT AT 20-30 M/S
- THE GMF ENABLES THE ESTIMATES OF ABOVE 50 M/S WIND SPEEDS - BETTER AGREEMENT WITH THE NHC TRACK ANALYSIS
  - EVEN WITH THE PRESENCE OF RAIN
- QSCAT 12.5 KM WINDS AND SIGMA0 ENABLE AN IDENTIFICATION OF THE EYE WALL SIZE AND POSITION